

# Reconocimiento de Patrones

Version 2022-2

## Local Binary Patterns

[ Capítulo 2 ]

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Director Semillero TRIAC

Ingeniería Electrónica

Universidad Popular del Cesar

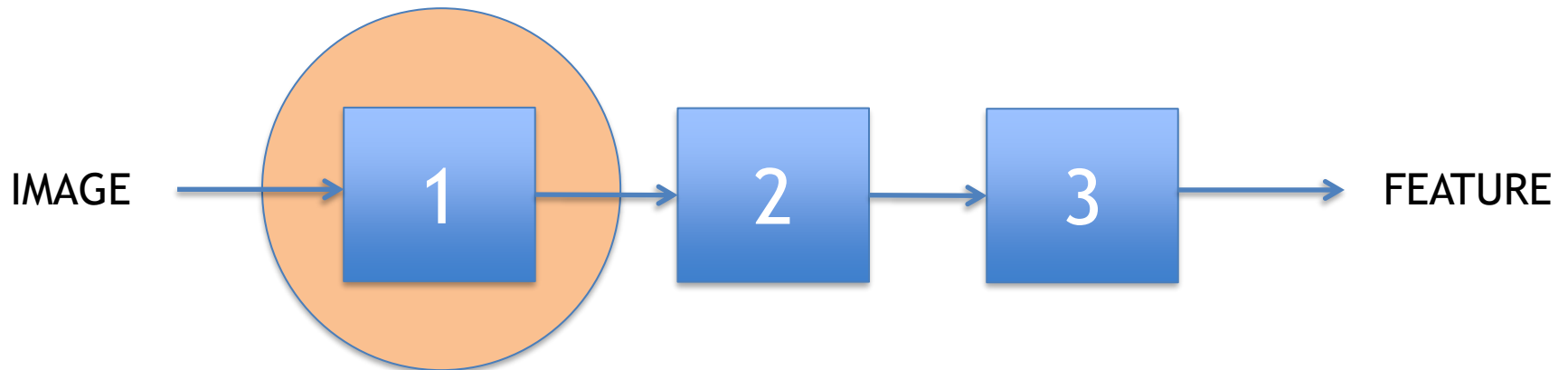
# Local Binary Patterns

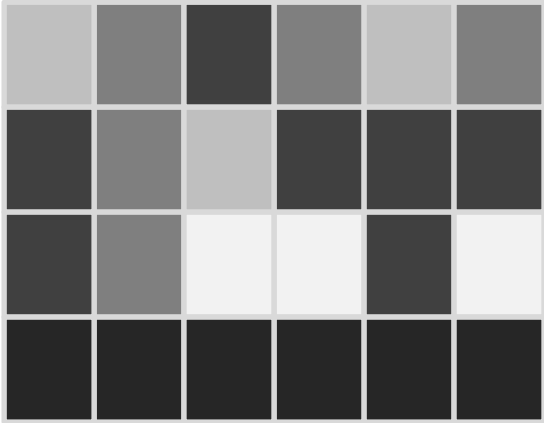
1. Coding
2. Mapping
3. Histogram



# Local Binary Patterns

1. Coding
2. Mapping
3. Histogram





4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

<		



4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

0		

0: <  
1: ≥

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

0	$\geq$	

0: <  
1:  $\geq$

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

0	1	

0: <  
1: ≥

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

0	1	1

0: <  
1: ≥

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

0	1	1
		0

0: <  
1: ≥

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

0	1	1
		0
		0

0: <  
1: ≥

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

0	1	1
		0
	1	0

0: <  
1: ≥

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

0	1	1
		0
1	1	0

0: <  
1: ≥



4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

0	1	1
1		0
1	1	0

0: <  
1: ≥

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

0: <  
1: ≥

0	1	1
1		0
1	1	0

x

1	2	4
128	+	8
64	32	16

$$= 2+4+32+64+128 = 230$$

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

4	6	9
9	6	4
9	6	2

0: <  
1: ≥

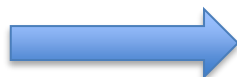
0	1	1
1		0
1	1	0

x

1	2	4
128	+	8
64	32	16

$$= 2+4+32+64+128 = 230$$

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10



	230				

4	6	9
9	6	4
9	6	2

0: <  
1: ≥

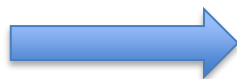
0	1	1
1		0
1	1	0

x

1	2	4
128	+	8
64	32	16

$$= 2+4+32+64+128 = 230$$

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10



	230	?			

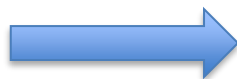
6	9	6
6	4	9
6	2	2

0: <  
1: ≥


x

1	2	4
128	+	8
64	32	16

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10



	230	207			

6	9	6
6	4	9
6	2	2

0: <  
1: ≥

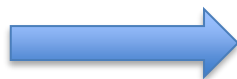
1	1	1
1		1
1	0	0

x

1	2	4
128	+	8
64	32	16

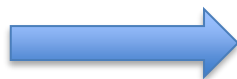
$$= 1+2+4+8+64+128 = 207$$

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10



	230	207	?		

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10



	230	207	25		

9	6	4
4	9	9
2	2	9

0: <  
1: ≥

1	0	0
0		1
0	0	1

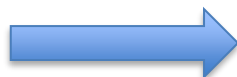
x

1	2	4
128	+	8
64	32	16

$$= 1+8+16 = 25$$

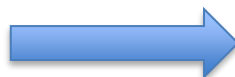


4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10



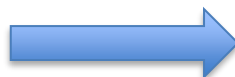
	230	207	25	168	

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10



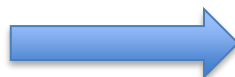
	230	207	25	168	
	243				

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10



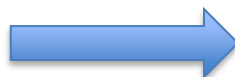
	230	207	25	168	
	243	255			

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10



	230	207	25	168	
	243	255	255		

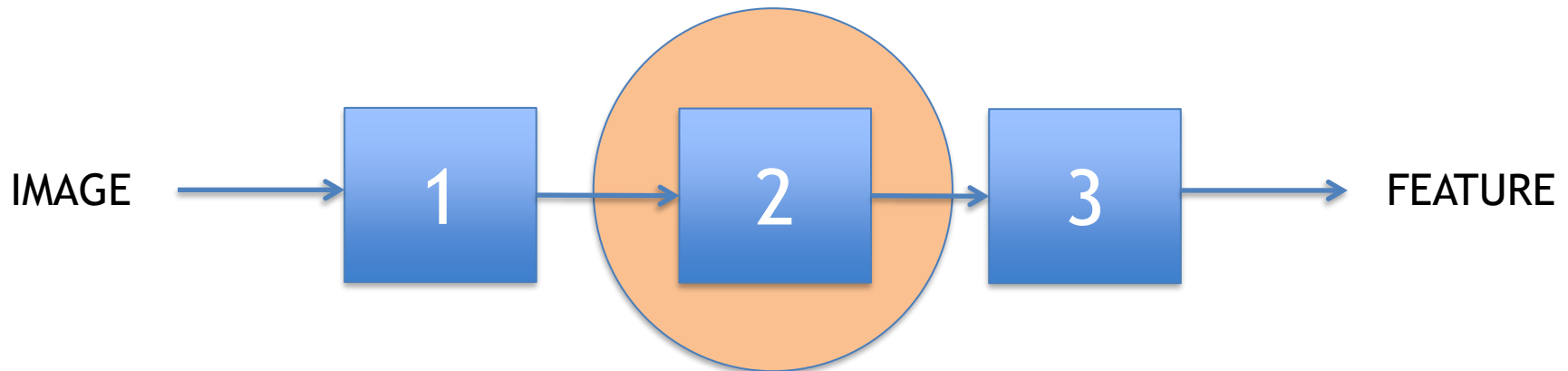
4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10



	230	207	25	168	
	243	255	255	119	

# Local Binary Patterns

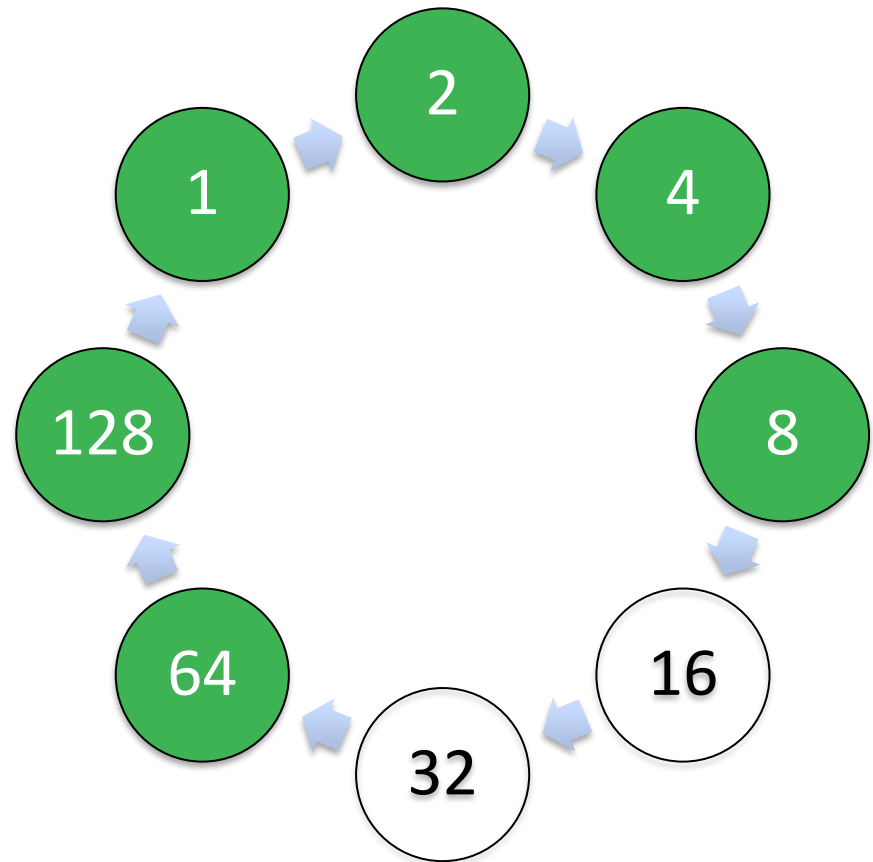
1. Coding
2. Mapping
3. Histogram



6	9	6
6	4	9
6	2	2



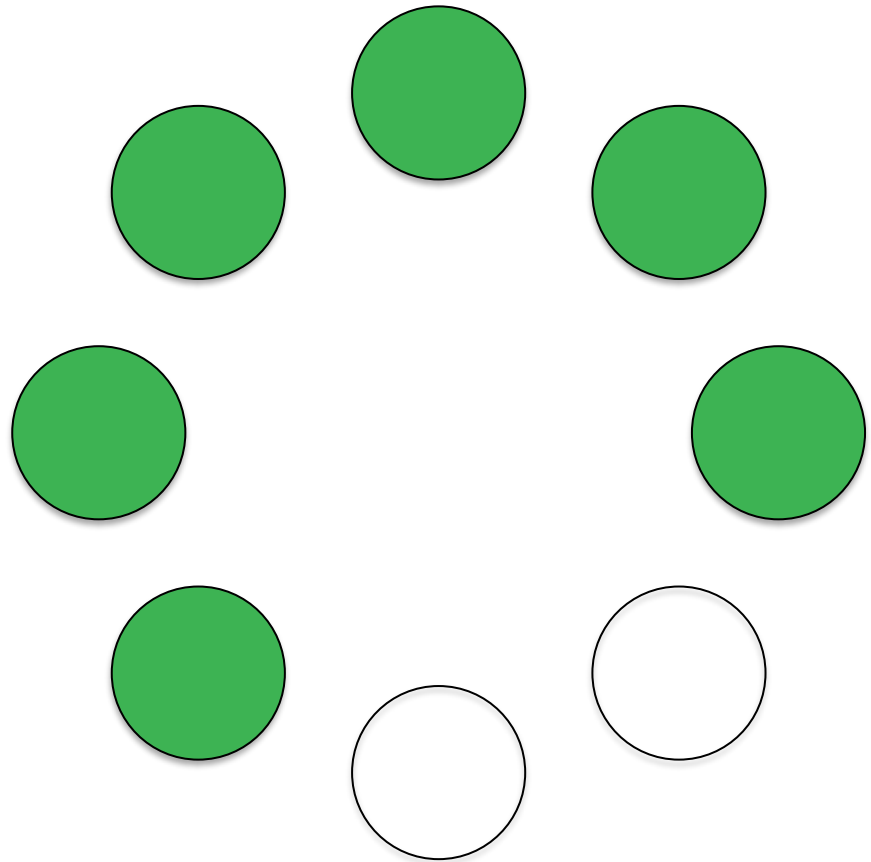
1	1	1
1		1
1	0	0



6	9	6
6	4	9
6	2	2



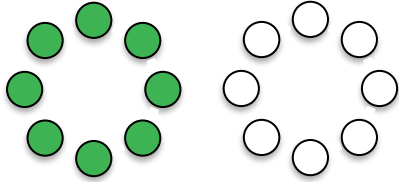
1	1	1
1		1
1	0	0



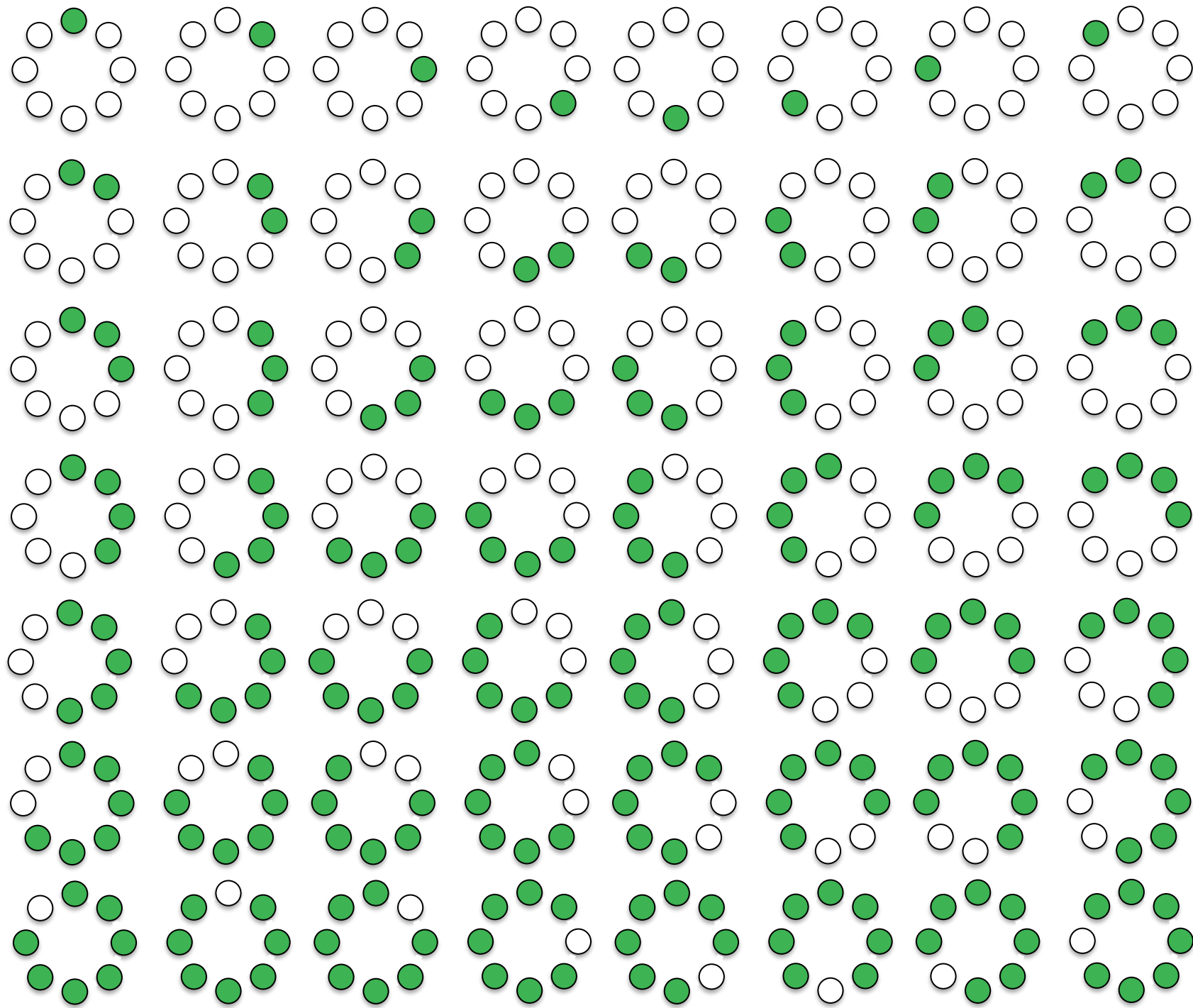


# Uniform patterns

$U = 0$



$U = 2$



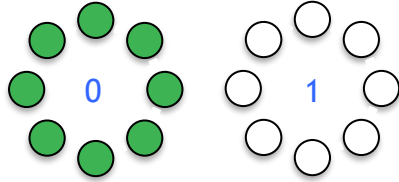
# Uniform patterns

$2 + 56 = 58$   
patterns

$U = 0$

2  
patterns

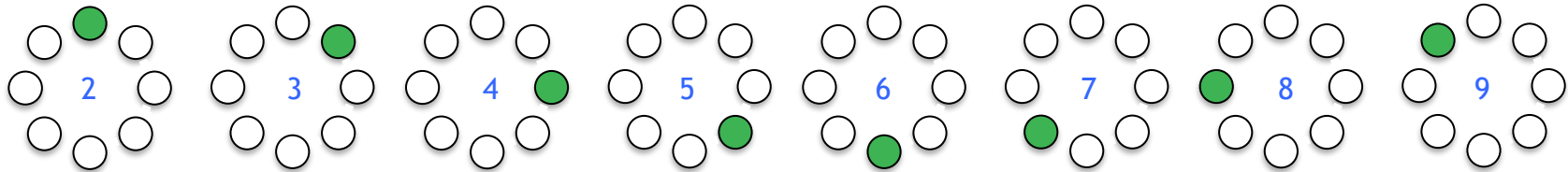
$\{0, 1\}$



$U = 2$

$8 \times 7 = 56$   
patterns

$\{2, 3, \dots, 57\}$



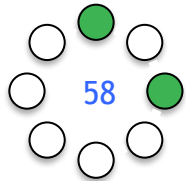
⋮

# Non-uniform patterns

$256 - 58 = 198$   
patterns

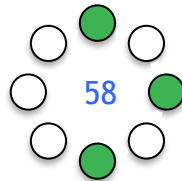
$\{58\}$

$U = 4$



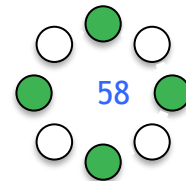
⋮

$U = 6$



⋮

$U = 8$



⋮

4	6	9	6	4	6
9	6	4	9	9	9
9	6	2	2	9	2
10	10	10	10	10	10

IMAGE



	230	207	25	168	
	243	255	255	119	

CODED  
IMAGE

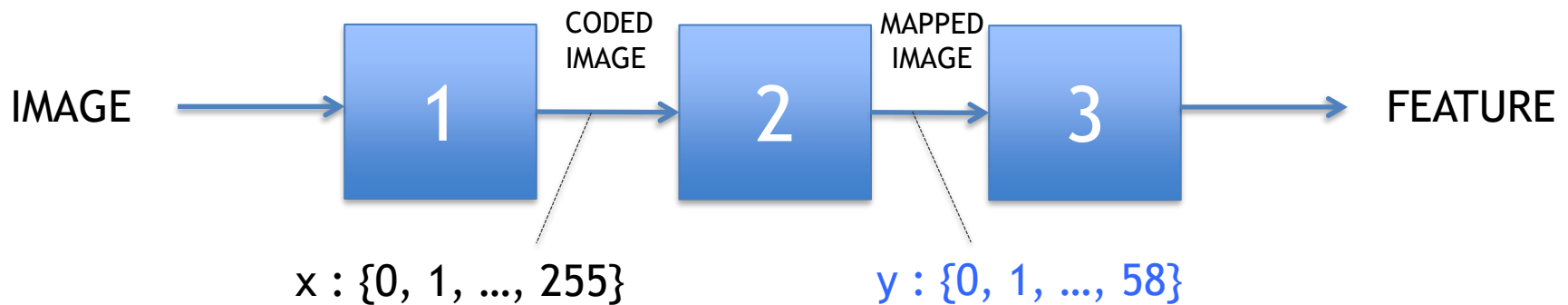


	58	46	58	58	
	23	1	1	58	

MAPPED  
IMAGE

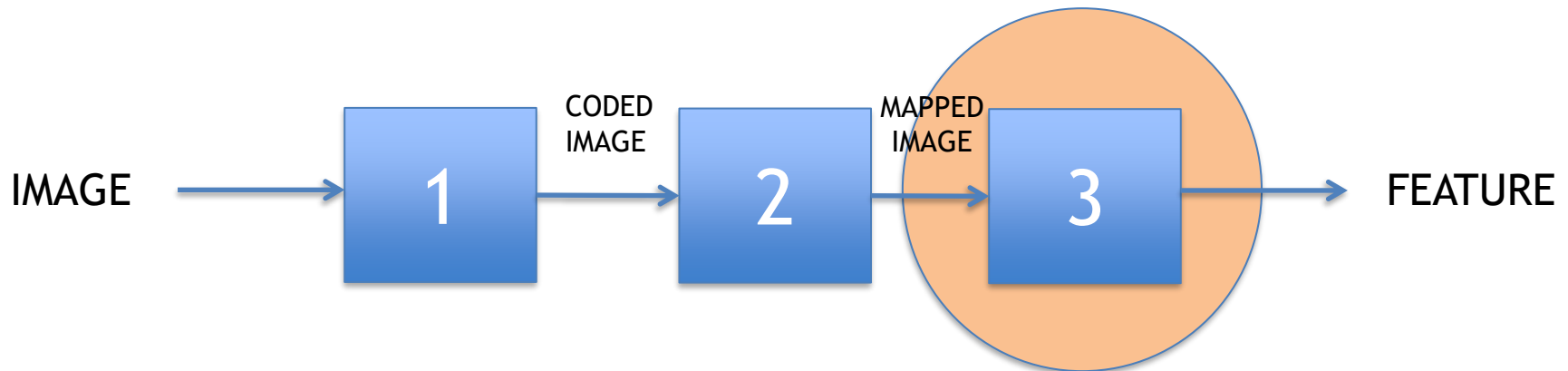
# Local Binary Patterns

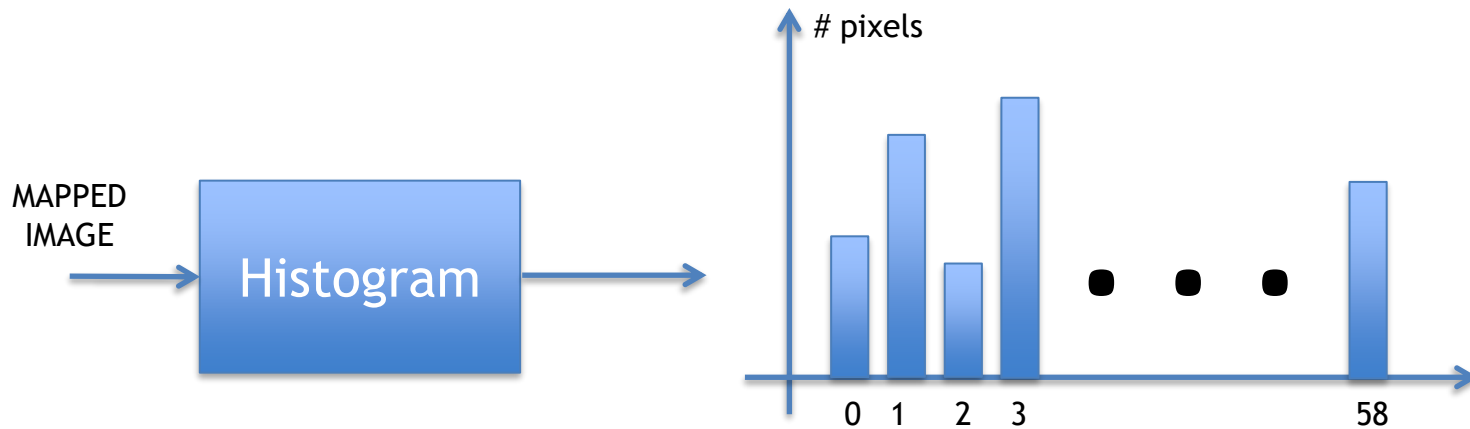
1. Coding
2. Mapping
3. Histogram



# Local Binary Patterns

1. Coding
2. Mapping
3. Histogram



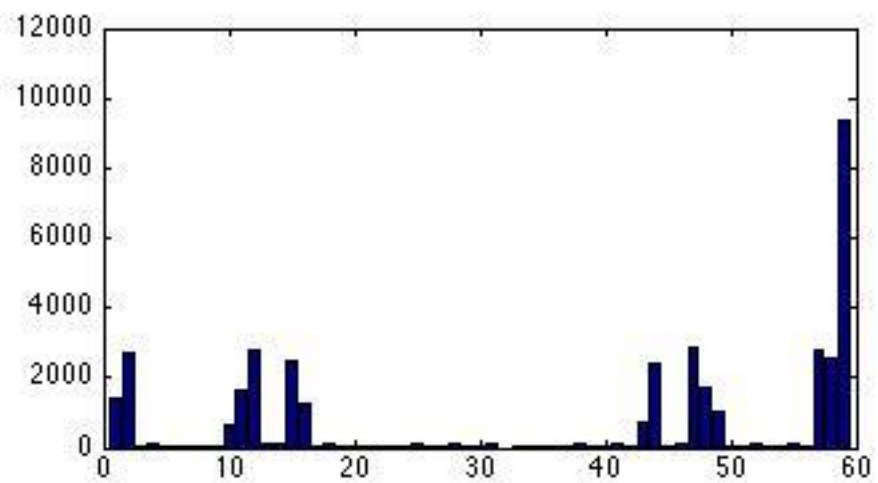
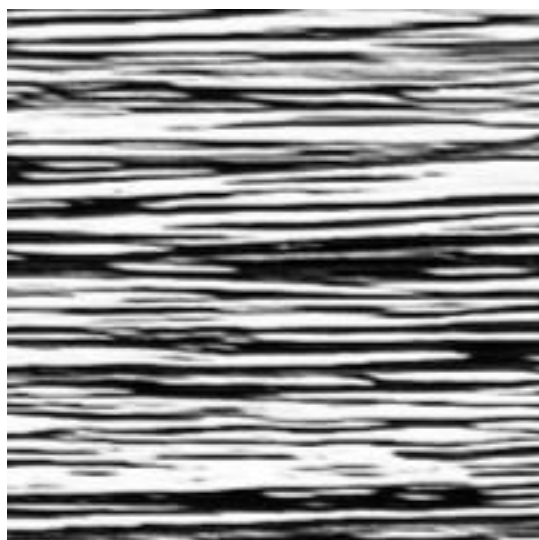
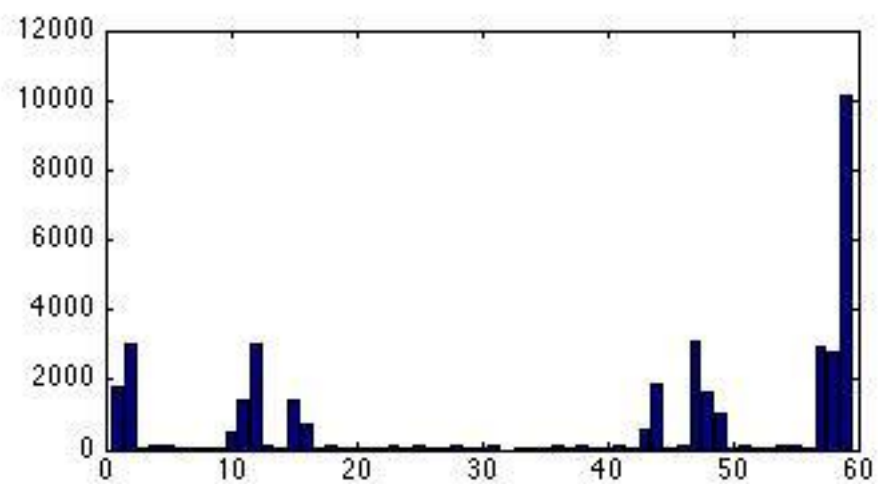
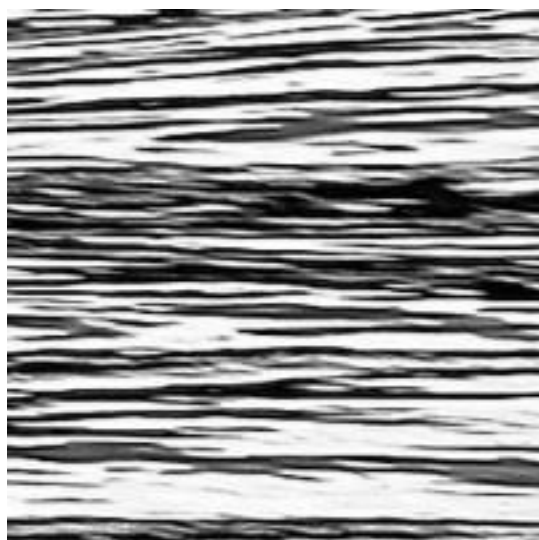


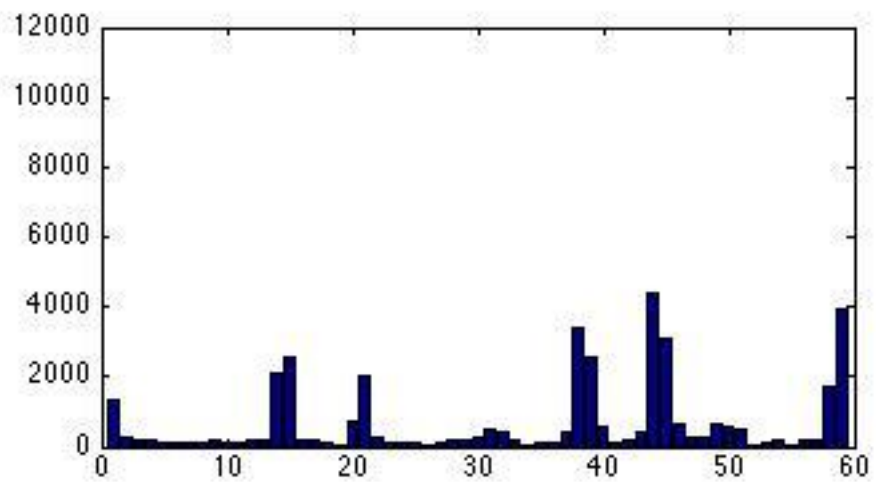
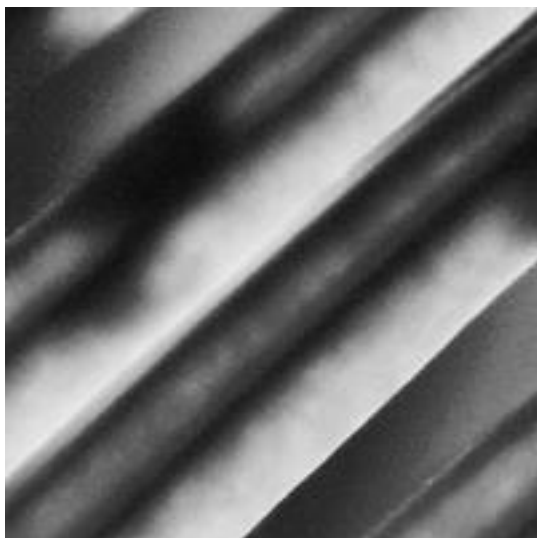
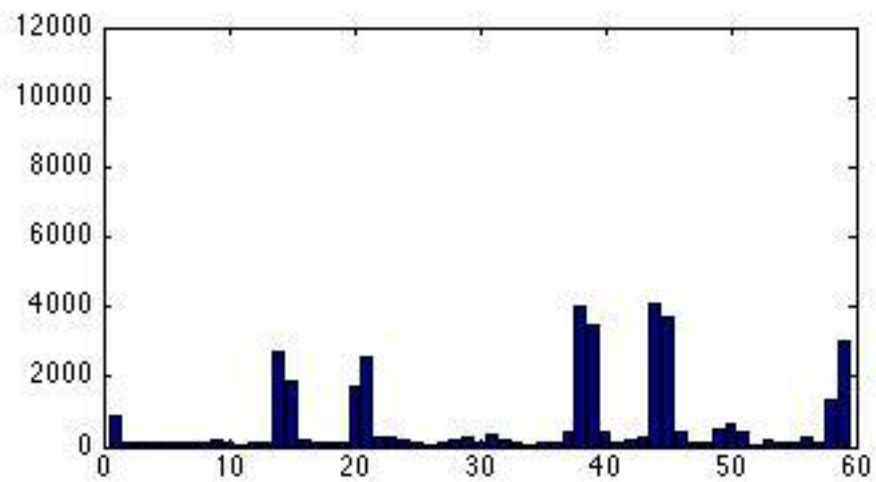
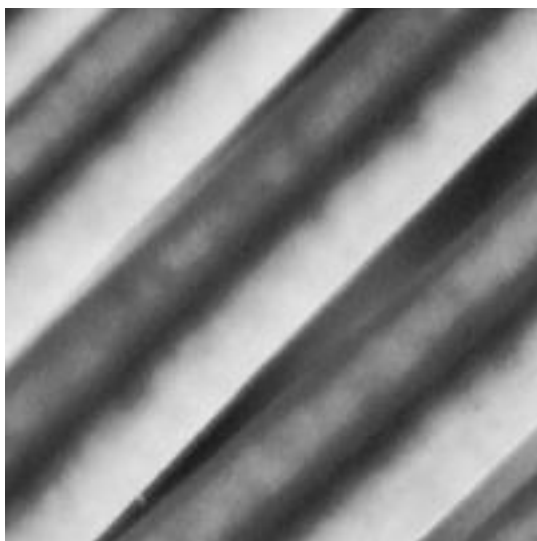
The image is described as a vector of 59 elements. Similar images have similar LBP features!!!

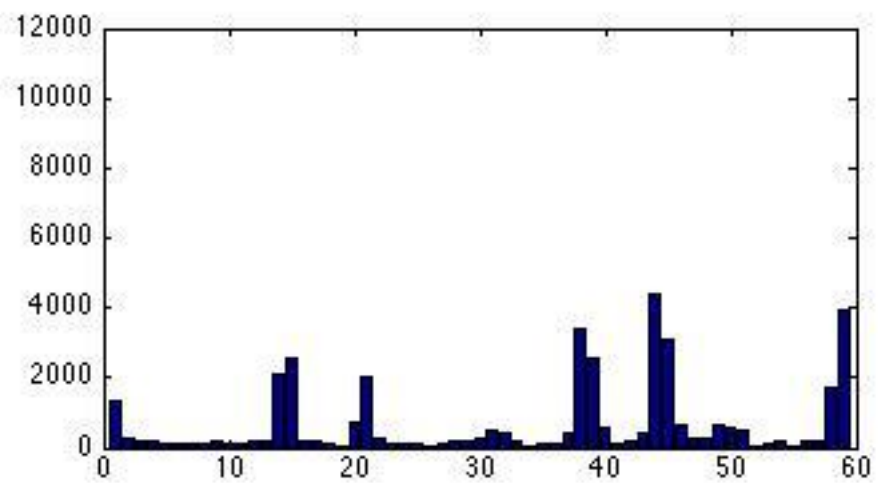
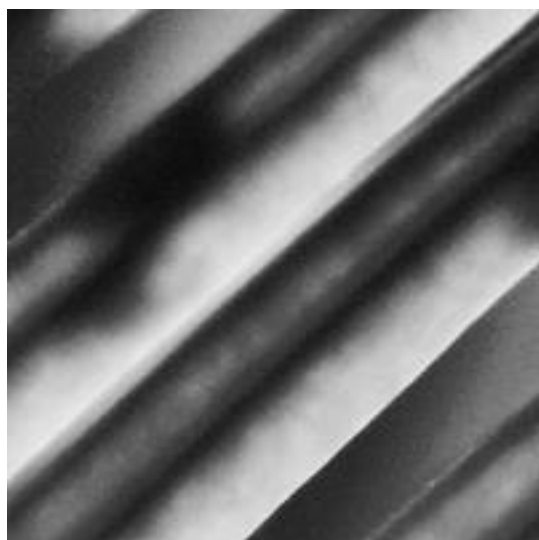
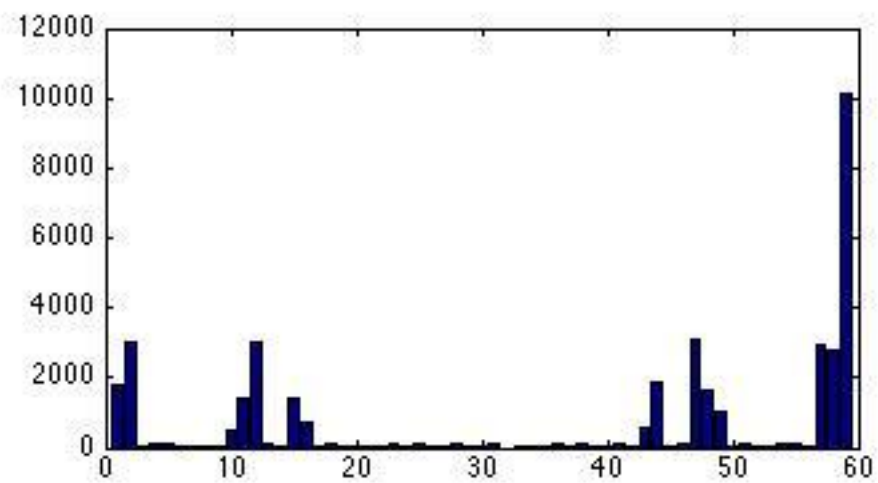
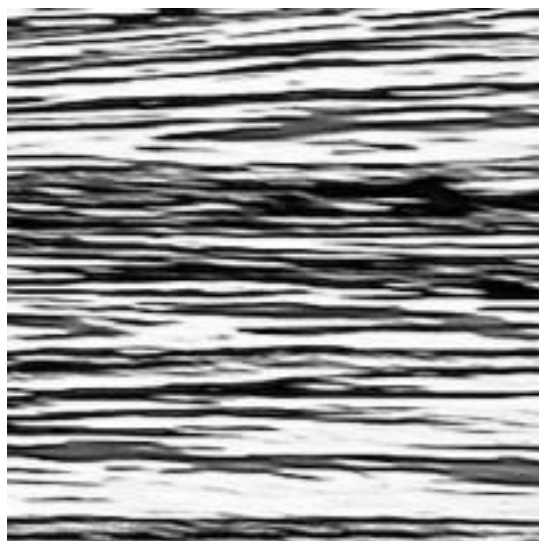
# Local Binary Patterns

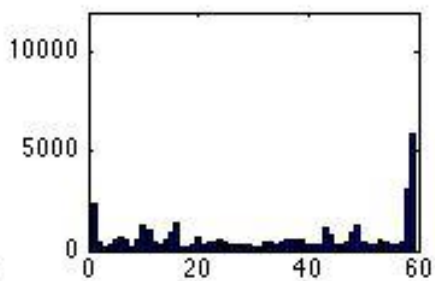
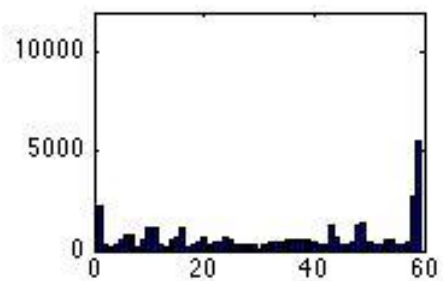
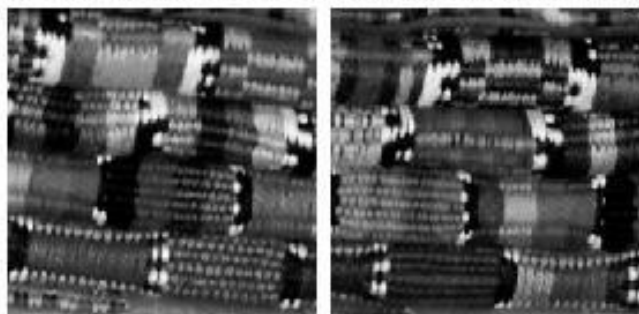
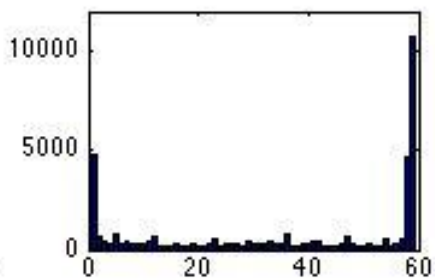
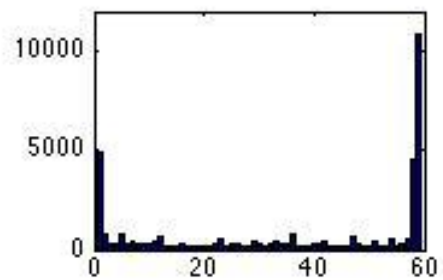
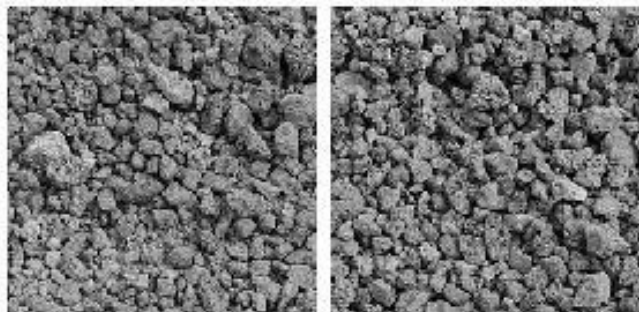
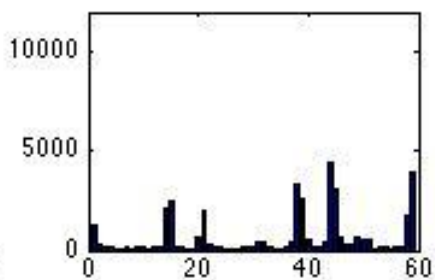
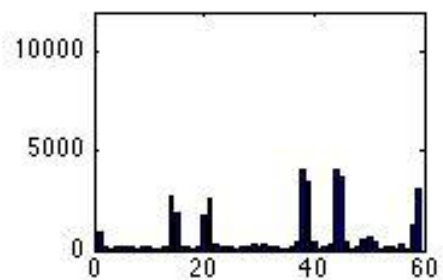
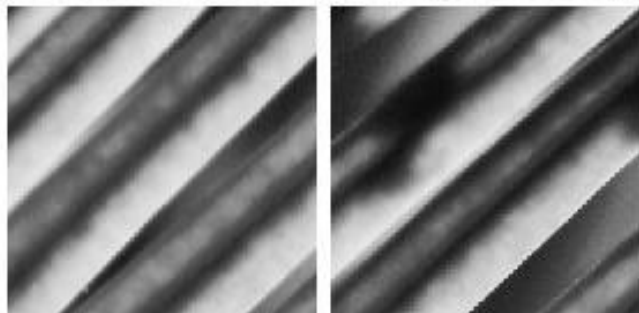
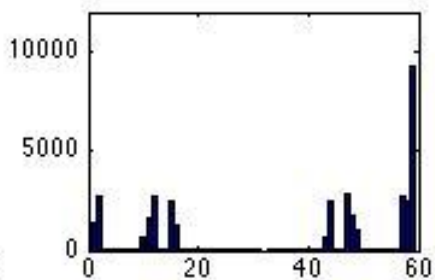
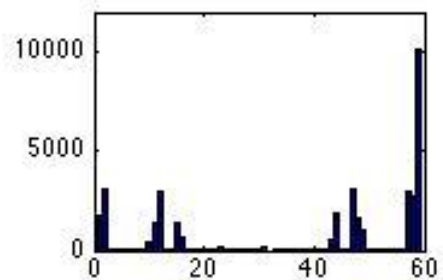
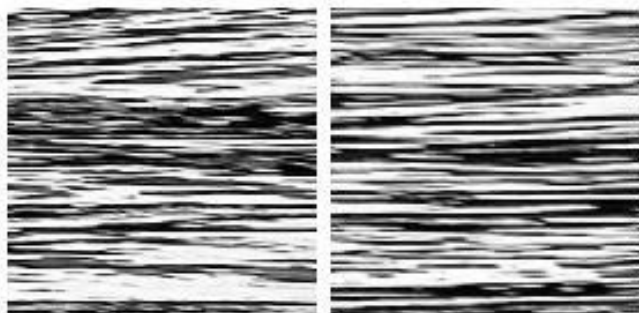
Examples  
Texture Images

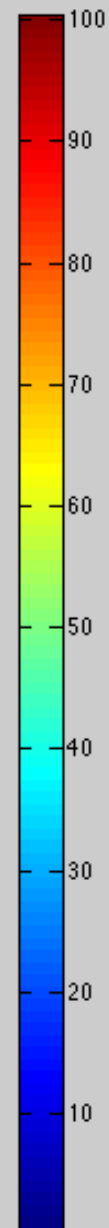
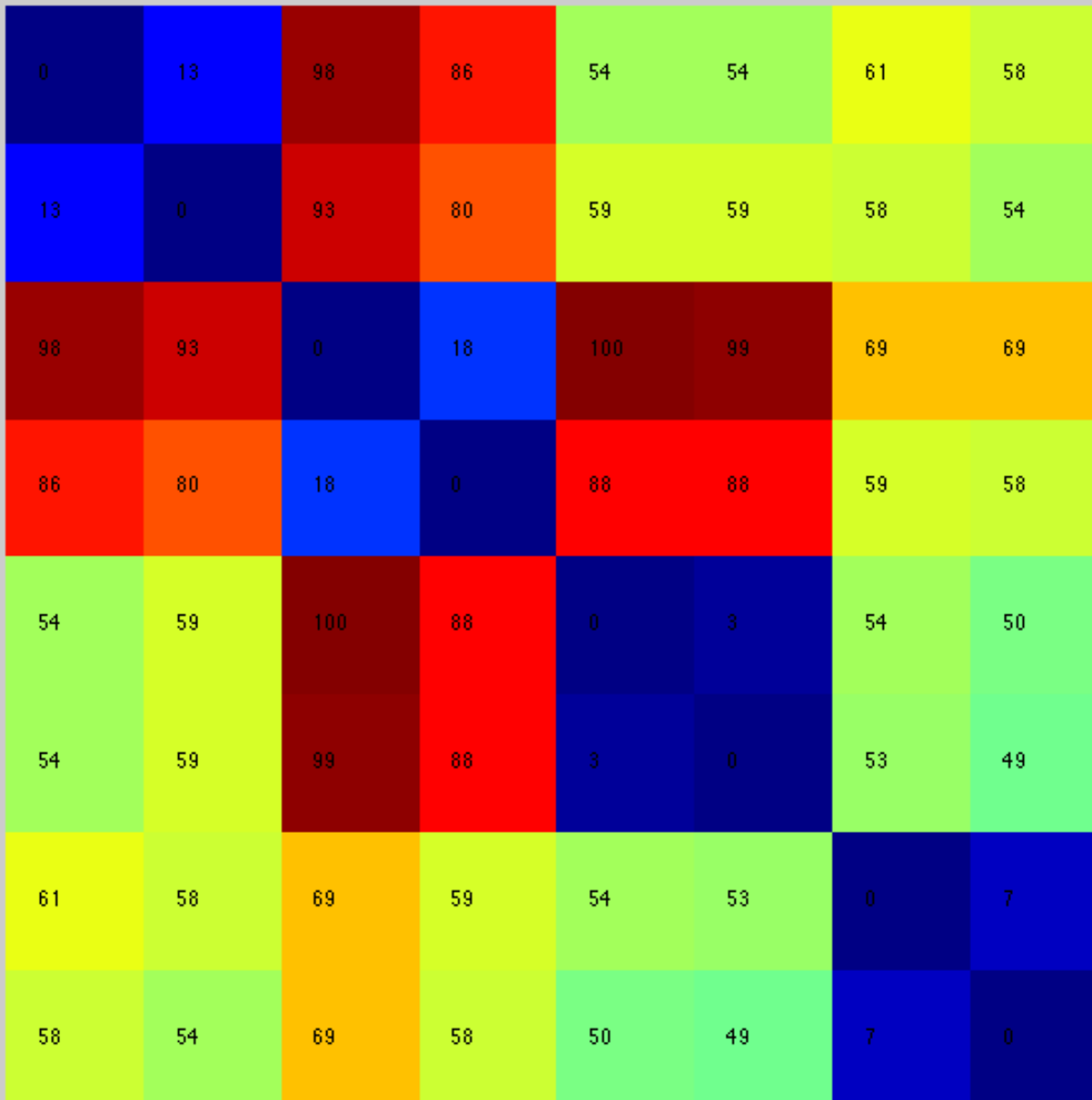
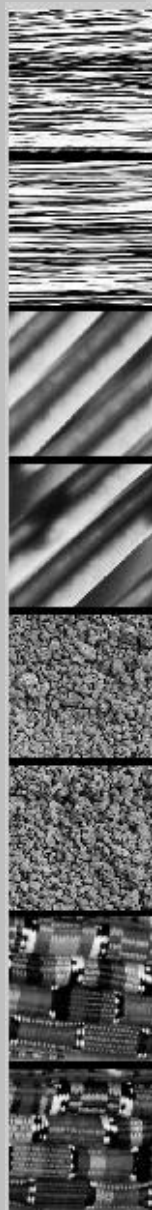
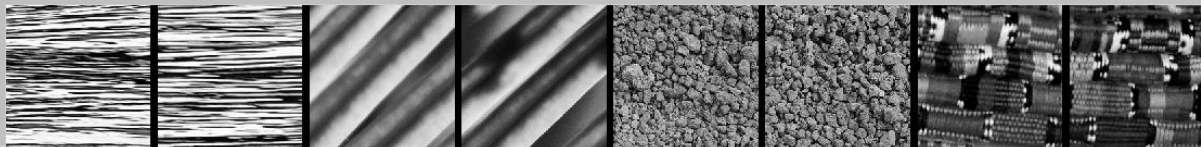












# Local Binary Patterns

Examples

Face Recognition





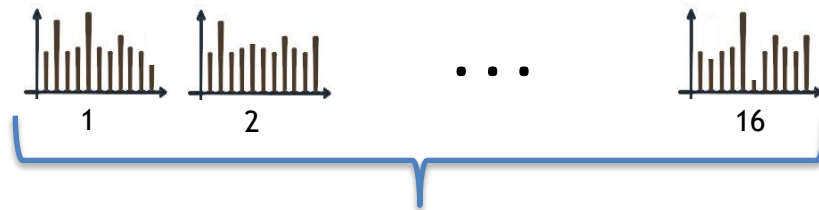
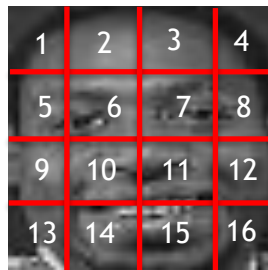
In the training set there are  $k$  classes.

For each class we have  $n$  training images.

In this example there are 40 classes with 9 images each.

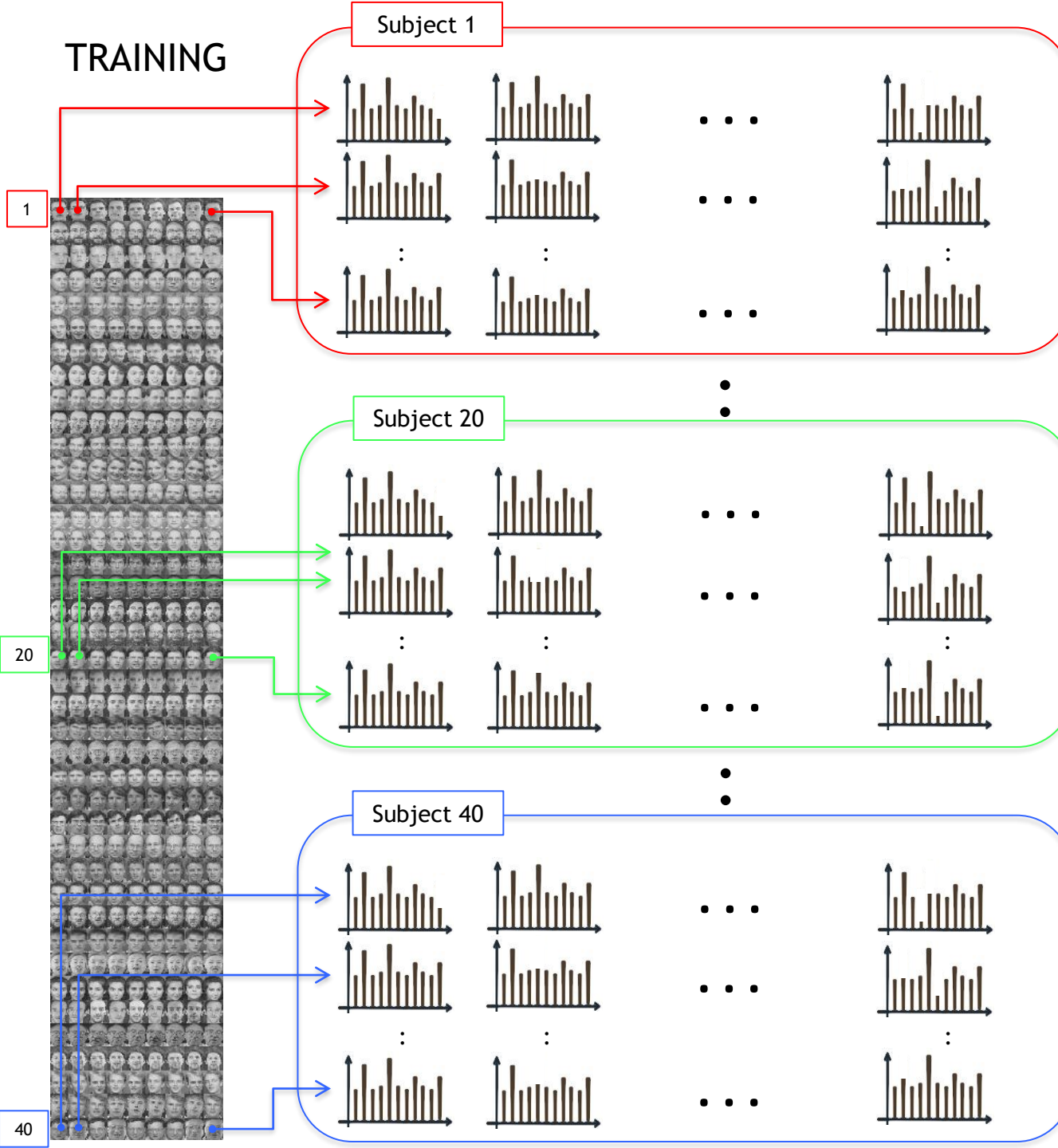
Each image we use  $w \times w$  partitions

In each partition we extract LBP feature



A face is described using a feature of  $16 \times 59 = 944$  elements

# TRAINING



Training Data:

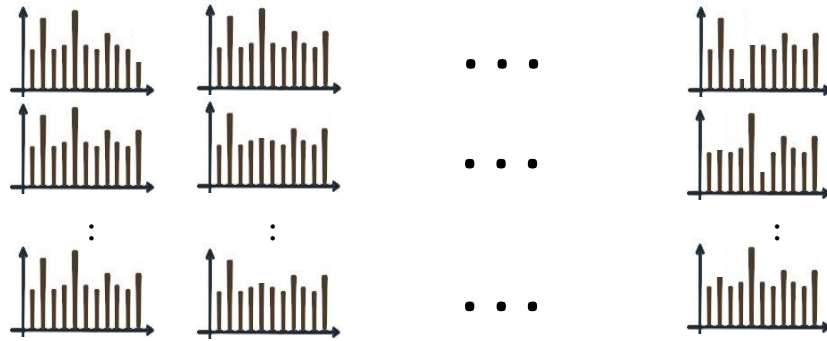
Table with:

$9 \times 40 = 360$  rows

$16 \times 59 = 944$  columns

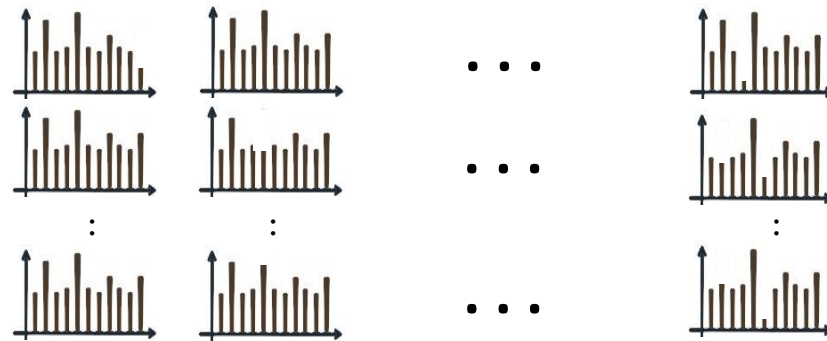


Subject 1



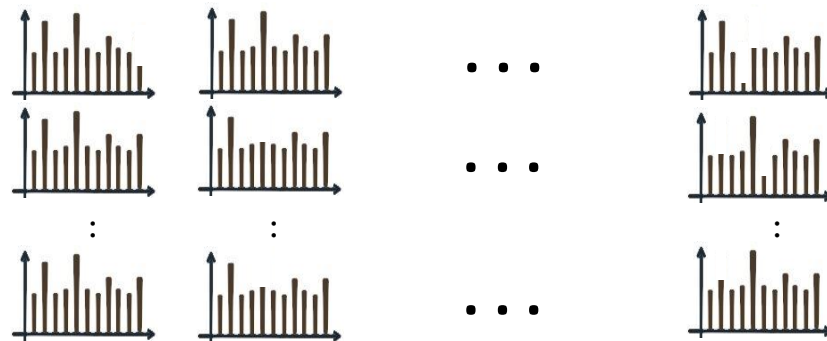
•  
•

Subject 20

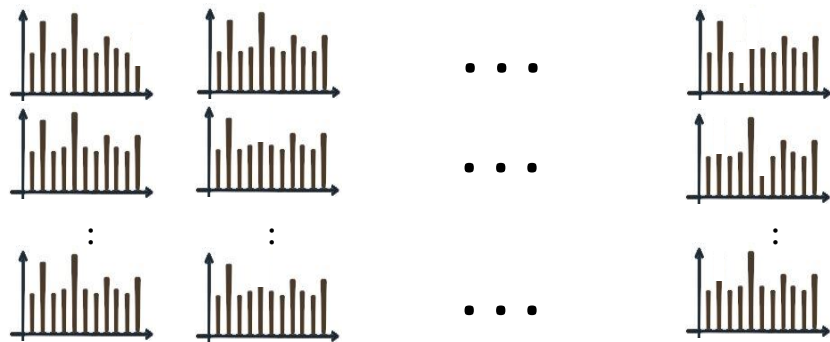


•  
•

Subject 40

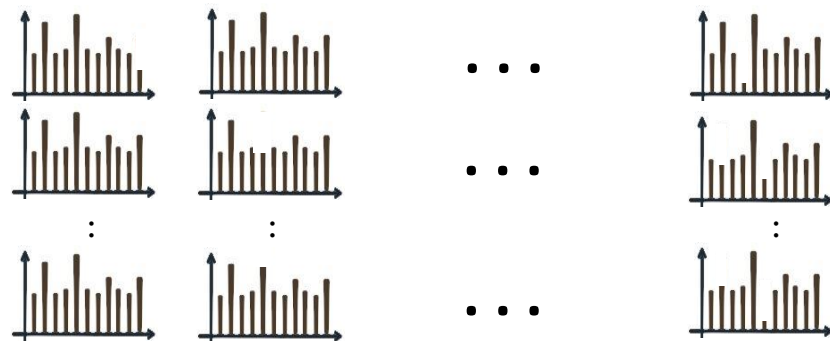


Subject 1



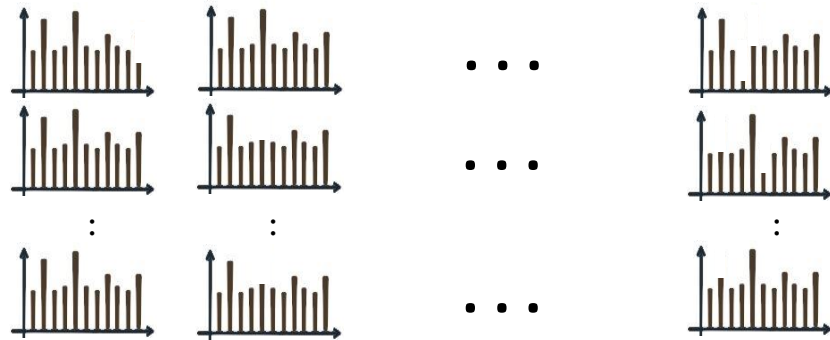
⋮

Subject 20

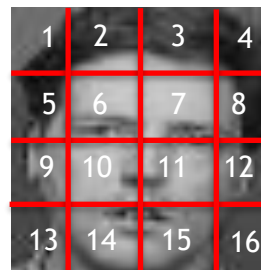


⋮

Subject 40



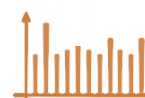
## TESTING



Who is this subject?



1



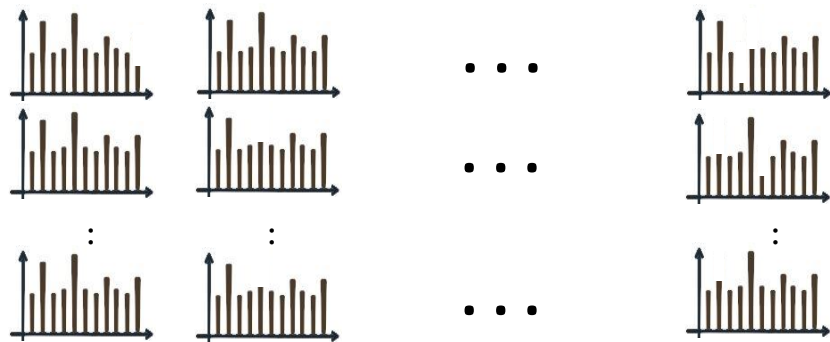
2

...

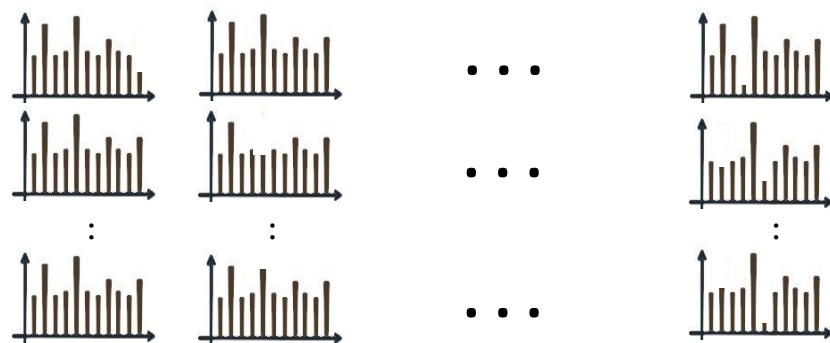


16

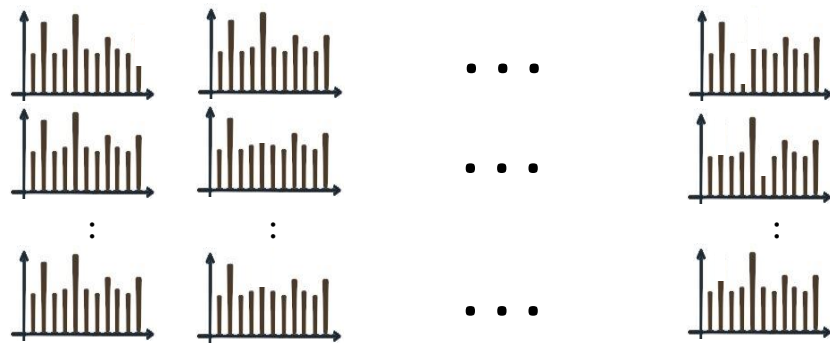
Subject 1



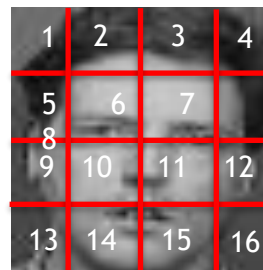
Subject 20



Subject 40



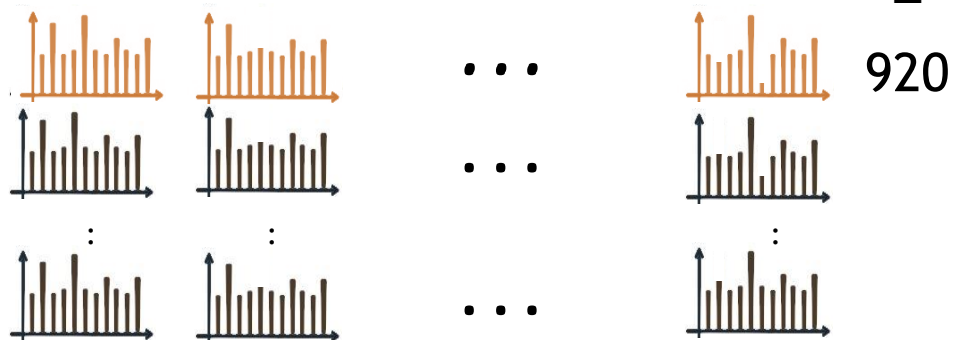
## TESTING



Who is this subject?



Subject 1

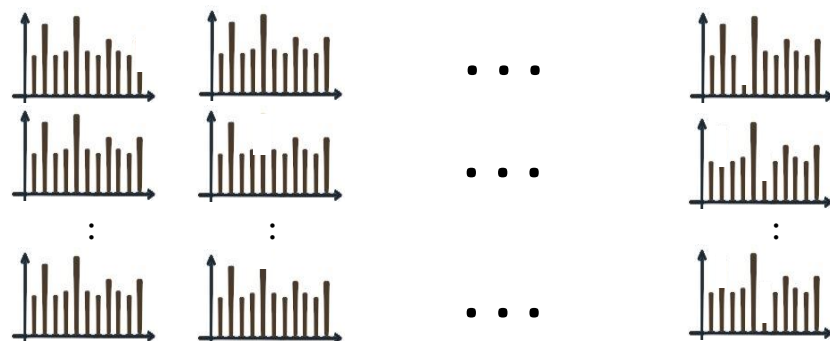


TESTING



Who is this subject?

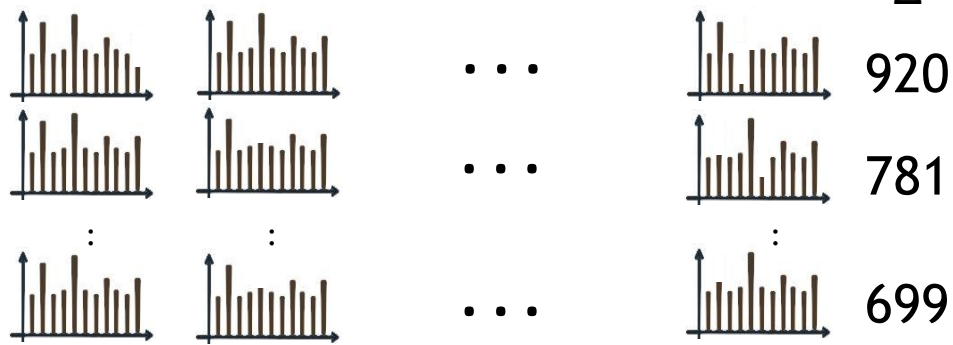
Subject 20



Subject 40



Subject 1



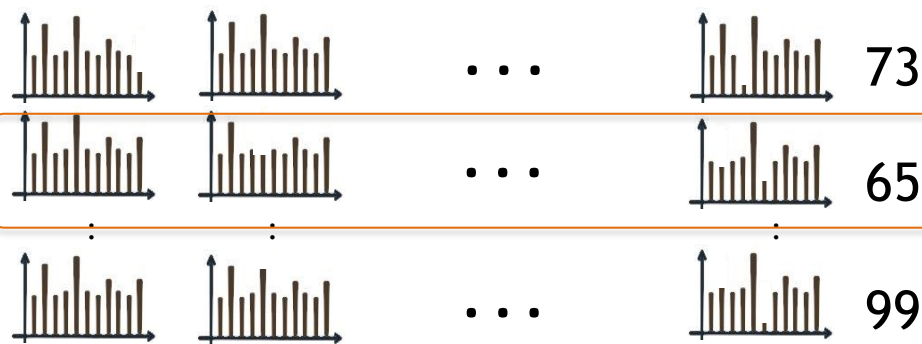
$\Delta$

TESTING



Who is this subject?

Subject 20



Minimum

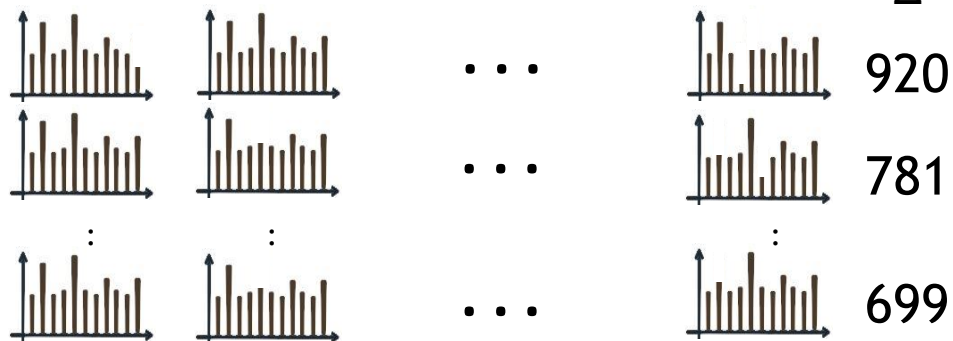
Subject 40



Strategy 1:  
*The nearest neighbor*

Strategy 2:  
k - nearest neighbors  
(knn)

Subject 1

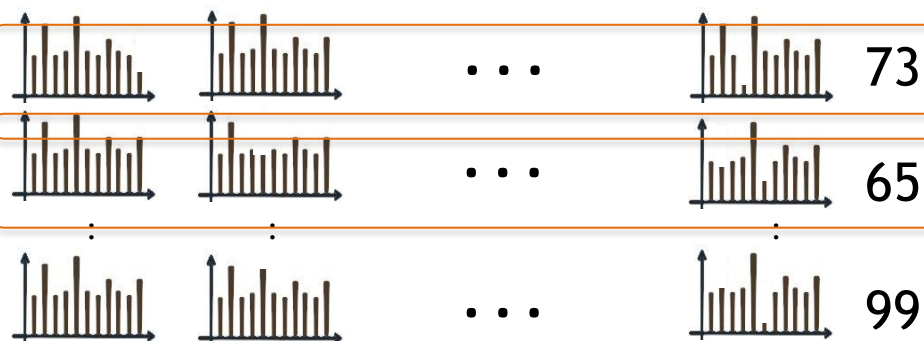
 $\Delta$ 

TESTING

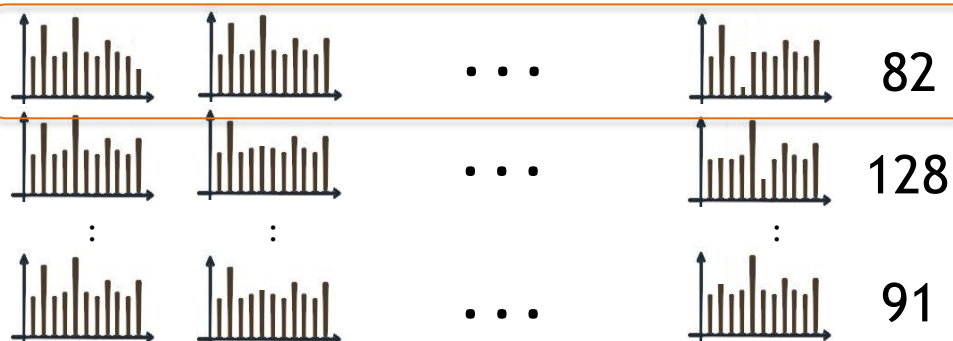


Who is this subject?

Subject 20

2<sup>nd</sup> Minimum > Subject 201<sup>st</sup> Minimum > Subject 20

Subject 40

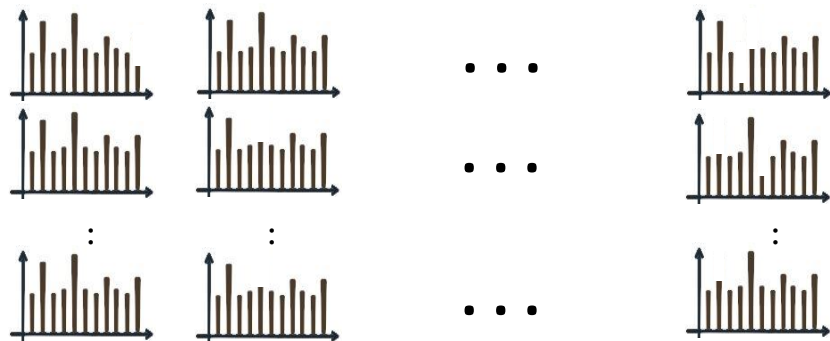
3<sup>rd</sup> Minimum > Subject 40

Strategy 2:  
*k-nearest neighbor* (k=3)

Strategy 3:  
smallest sample-class  
distance



Subject 1

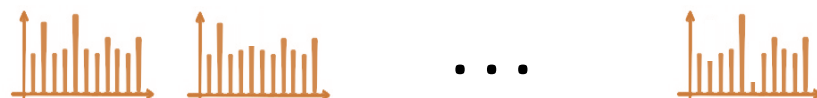
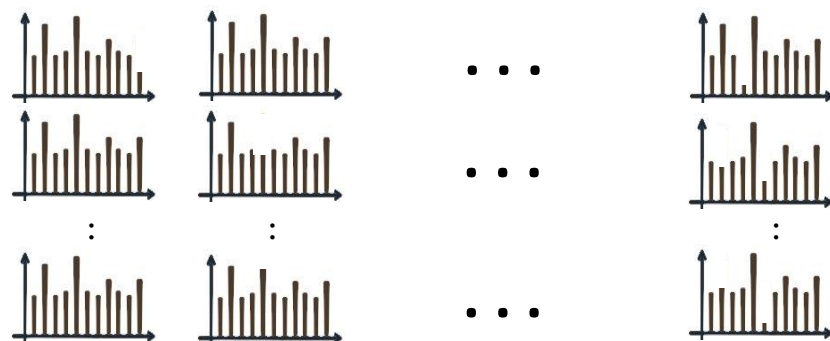


TESTING



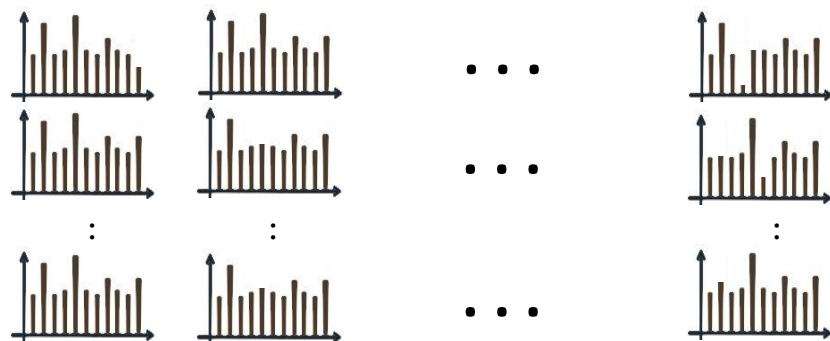
Who is this subject?

Subject 20

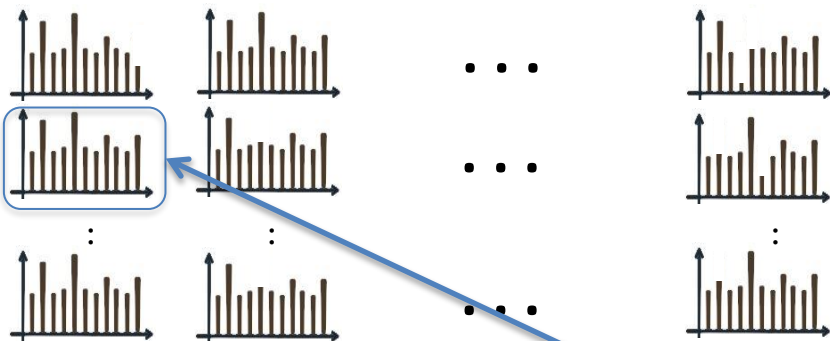


Minimal distance

Subject 40



Subject 1



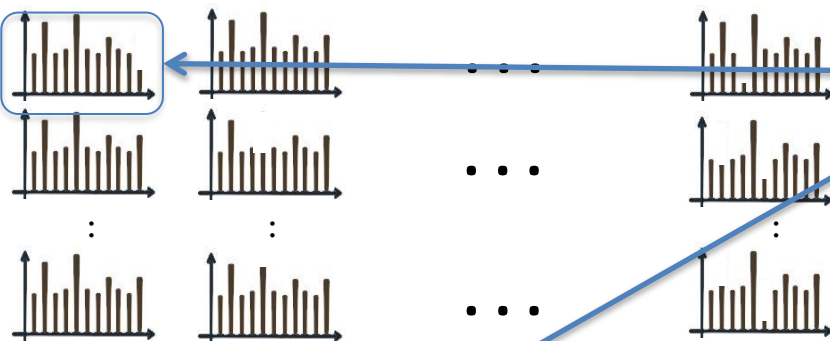
$\Delta$   
120

TESTING

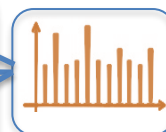


Who is this subject?

Subject 20



23

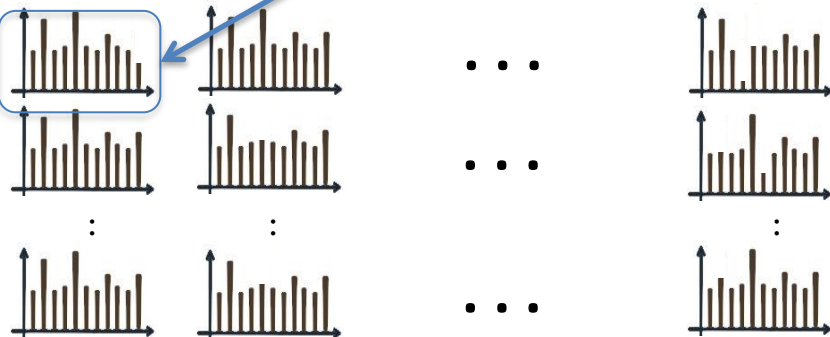


...



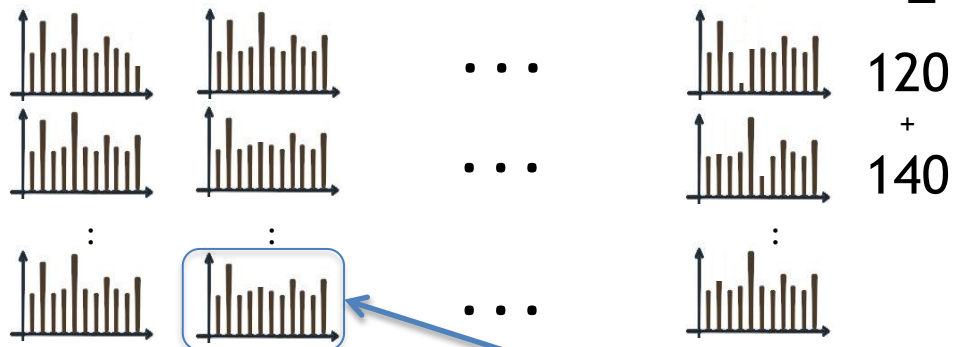
Minimal distance

Subject 40



12

Subject 1



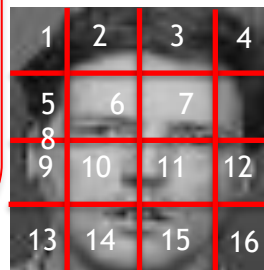
$\Delta$

120

+

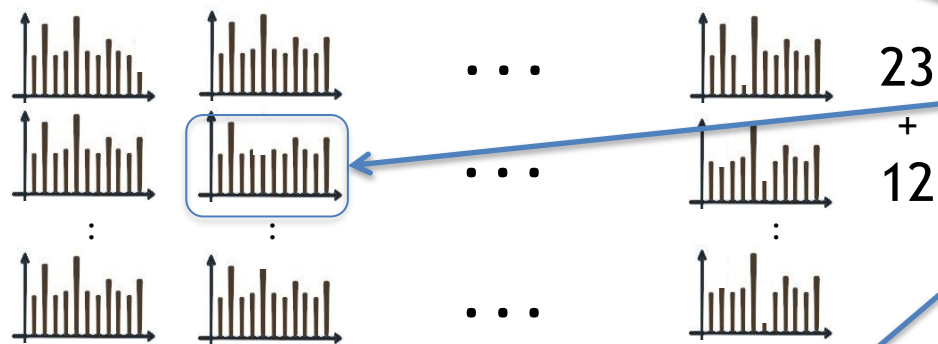
140

TESTING



Who is this subject?

Subject 20



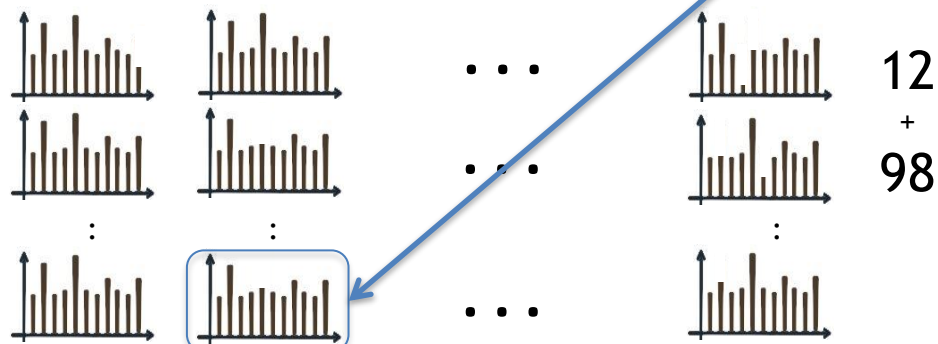
23

+

12

Minimal distance

Subject 40

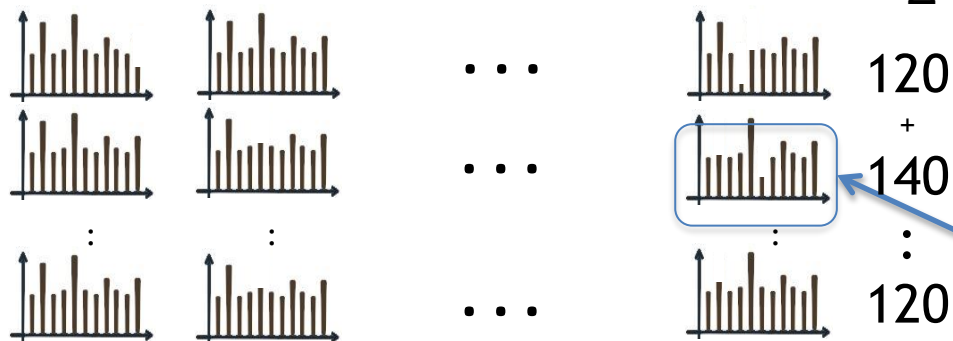


12

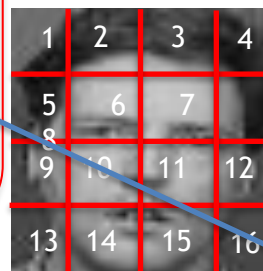
+

98

Subject 1

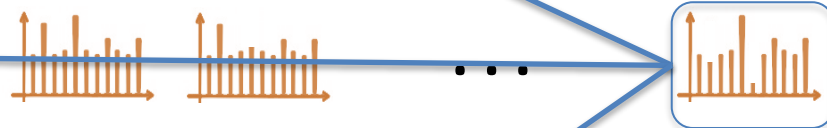


TESTING



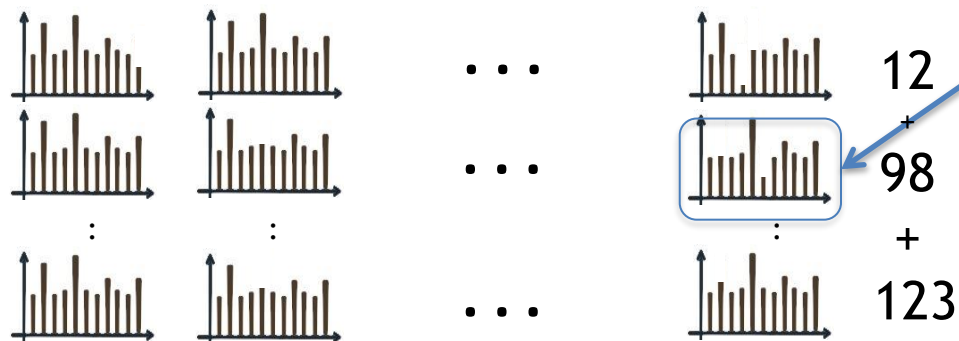
Who is this subject?

Subject 20

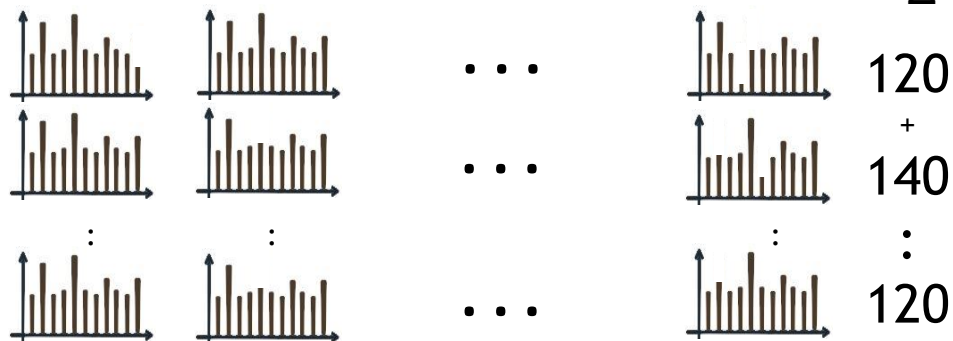


Minimal distance

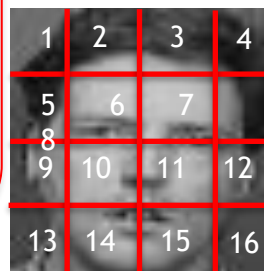
Subject 40



Subject 1



TESTING



Who is this subject?

Subject 20



= 54

Minimal total distance

Subject 40

